ARMED FORCES CHEMICAL JOURNAL

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CHEMICAL WARFARE IN 1915 AND NOW

"I think the conclusion I have reached tentatively will not be accepted by the majority of your readers, but they may be interested in the opinion of a person with first-hand knowledge of conditions in 1915 who could attempt to make a comparison between the two periods."

Major General C. H. Foulkes,
C.B., C.M.G., D.S.C.

ARMED FORCES CHEMICAL ASSOCIATION

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THE Armed Forces Chemical Association is a patriotic, educational, scientific, nonpolitical and nonprofit-making organization of citizens of the United States of America dedicated to scientific and industrial preparedness for the common defense in the fields of chemical, biological, radiological and related technology, commonly referred to as chemicals. Objectives of the Association are to encourage chemical research and development, among private, industrial, educational, and research organizations in cooperation with the agencies of the Department of Defense. To bring to the people of our country the knowledge for the necessity of scientific and industrial preparedness; and to encourage adequate military training throughout the Nation and the upbuilding of adequate enlisted and commissioned Reserves; to assist in developing and maintaining adequate personnel, both commissioned and enlisted, for the requirements of the Military Establishment and Civil Defense in the event of an emergency. In pursuit of these objectives, the Association will provide, when required, the services of competent committees to investigate and report on special chemical subjects; will promote mutual understanding between American scientists, inventors, engineers, and manufacturers in civil life, and personnel of the Armed Forces. And, the Association will cooperate with all agencies of the Government in planning mobilization and untilization of the Nation's scientific and industrial resources for the national security.

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POLICY

The fact that an article appears in this magazine does not indicate approval of the views expressed in it by any one other than the author. It is our policy to print articles on subjects of interest in order to stimulate thought and promote discussion; this regardless of the fact that some or all of the opinions advanced may be at variance with those held by the Armed Forces Chemical Association, National Officers, and the Editors. It is the responsibility of contributors, including advertisers, to obtain security clearance, as appropriate, of matter submitted for publication. Such clearance does not necessarily indicate indorsement of the material for factual accuracy or opinion by the clearing agency.

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Chemical Warfare In 1915

BY MAJOR GENERAL C. H. FOULKES,
C.B., C.M.G., D.S.C.

Part One of Then and Now

By tradition, the Corps of Royal Engineers has been charged with the responsibility for developing almost every innovation in the history of the British Army, from battering rams to mechanical transport, wireless, aircraft and armoured vehicles; so that when Sir John French was given belated permission by the Cabinet[1] to retaliate against the Germans for their use of gas in April, 1915, he turned to his Engineer Adviser (as the Engineer-in-Chief was then called) and asked him to choose an officer to undertake the necessary preparations—preferably one with an intimate acquaintance of front-line conditions—and he nominated me. I was a very junior Major at the time, but had commanded a Field Company for the previous 9 months in the most active sections of the British front, from 1st Ypres onwards; and it was in this rather haphazard manner that I became "Gas Adviser" to the Commander-in-Chief, though it was known that I had but an elementary knowledge of chemistry, and, of course, no experience whatever of poison gases. I was promoted to Lieutenant-Colonel, and given a free hand, and told to stage a gas attack in about six weeks' time as a preliminary to a joint Anglo-French offensive that was planned for July 10th.

On visiting London I soon realized the toughness of this assignment. I learned that before the war Germany had enjoyed a monopoly of the chemical industry in Europe, and that the only gas that it was then possible for us to use, and that was manufactured in small quantities in England, chiefly in the Castner-Kellner factory at Runcorn on the Manchester Ship Canal, was chlorine (which the Germans were believed to have used) and that it could be liquefied for storage. But there was no practical method of discharging it into the open air, and the containers in commercial use were far too unwieldy for installation in narrow trenches. A week later a method of discharge on the soda-water syphon principle had been improvised and I witnessed a demonstration at Runcorn at which a few cylinders were emptied. This showed the behaviour of the gas as it was carried forward by the wind, the shape of the cones from the point of discharge and the distance at which they combined to form a continuous cloud; and it was from this simple demonstration that I had to plan our first gas attack. But the output of the factory had to be greatly increased and portable containers designed and manufactured, as well as suitable discharge pipes, all of which presented formidable difficulties in the circumstances.

I decided on cylinders without hesitation, though when I visited the French chemical establishment near Paris I found that they were proposing to generate their gas actually in the front line trenches, in iron receptables built into the parapet. The gas formed by a mixture of chemicals was to be forced out to the front through a pipe by means of rotary blowers. Such an apparatus, besides being immobile, would have been very vulnerable to bombardment, but it was interesting to note how an entirely novel problem was being approached by our allies and ourselves from quite different directions.

Personnel had also to be specially enlisted—largely from University graduates and students—and organised into Engineer units, and trained in handling the cylinders as soon as the first consignments arrived in France.

It was also evident, from the contempt with which the employees at Runcorn treated slight concentrations of chlorine, that some much more lethal agent had to be found, and an intensive research for it organized. A meteorological unit had to be formed for forecasting weather, and all my officers were trained in taking wind measurements. A small field chemical laboratory was also established, chiefly for intelligence purposes. (The Royal Army Medical Corps was providing protective masks, and training the troops in their use, but this responsibility, too, was transferred to me later in the war.)

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[1] With the proviso that the use of such deadly substances as Prussic acid was forbidden!

Chemical Warfare Now

BY MAJOR GENERAL C. H. FOULKES, C.B., C.M.G., D.S.C.

Part Two of Then and Now

In contrast to the circumstances I have described in 1915 a future Commander-in-Chief would have no difficulty in finding a ready-made gas adviser, especially in any army that included chemical formations. He would be trained already for the duty, and have at his disposal, stored and in quantity, substances considerably more dangerous than phosgene and mustard gas, as well as greater variety in the means of delivering them —for example, in aerial bombs of several types, and sprays—and he would have tested his tactics on the experimental field. (In the first war the British and German Air Forces had refused to have anything to do with gas.)

But we must avoid the error, of which I am giving several instances, of exaggerating the effects of new weapons before they have been proved.

(a) A week or two ago Don Iddon, in the British "Daily Mail", quoted an opinion expressed in the American magazine, "Look", which estimated that if Russia launched an all-out nuclear attack on the United States only four out of a hundred Americans would survive. In the case of a direct hit on a city, perhaps, but this seems a pessimistic forecast to make in regard to the scattered population of a whole Continent trained in protective measures.

(b) Soon after the end of the first war a prominent public man, and an amateur chemist, wrote a letter to the "Times" in which he said that a bomb containing one of the new arsenic compounds, if dropped in Piccadilly Circus, would destroy all life between that area and the Thames—perhaps a million people. In questioning the accuracy of this statement I pointed out that the substance referred to was not new, and had been used against our troops in France (in the German "Blue Cross" shells) for the last year of the war with very little effect; and I expressed the opinion[2] that an H.E. bomb of the same size would probably be much more destructive.

(c) And quite recently I have seen a similar statement made by an American authority whose views are entitled to the greatest respect. He is reported to have said that a single enemy missile could dispense enough "GB" (the "nerve" gas, Sarin) to produce 33 per cent of casualties among **all unmasked personnel in the open** over an area one mile in diameter. The bold words are mine.

(d) Between the two wars a group of scientists in one of our Universities published a paper that gave the results of a series of experiments they had made on the protection afforded by air raid shelters against gas, which had shown that even a two foot thickness of concrete wall was insufficient to prevent penetration. "Nature" asked me to review this publication, and in doing so I expressed disbelief, and remarked that two old army blankets, hung on a wooden frame at the entrance to a dugout in France, had been found to give its occupants sufficient protection for all practical purposes.

It is only with diffidence that I am now venturing to speculate on the future possibilities of chemical warfare, in view of the fact that I am in possession of no official secrets. I have, however, seen a good deal that has been openly published here and in the United States about the chemical and biological agents that have been investigated recently, of which the "nerve" gases seem to be considered the most dangerous. Perhaps Mr. Ian Fleming, the novelist, is better informed; for in one of his books he introduces a nerve gas, as a narcotic, into the reservoirs supplying water to the whole district around Fort Knox, to enable a gang of super-criminals to put the entire population out of action for three days,

[2] The Correspondence Editor of the *Times* called me on the telephone to say that he proposed to publish my letter, except for one remark. "What," I said, "has the *Times* no courage?" "Lots of it," he answered, "but also due respect for the law of libel." The writer of the letter referred to was a King's Counsel!

the time required to empty the vaults of their tons of gold.

(1) It is generally supposed that there is now such a balance in nuclear equipment between East and West that a stalemate has been created; and that unless a war "happens" through accident or miscalculation—for example, as a consequence of providing fighter protection for our approaches to Berlin—mutual fear has made war between any of the Great Powers unthinkable. If this is true, no armaments will come into use except psychological broadsides, a "nerve" weapon in a different sense.

But after such near miracles of achievement as photographing the back of the moon, nuclear fission and television, no scientific discovery is inconceivable. It is already possible to trigger off, from the ground, mechanisms carried in space vehicles, and it would only be a step further to find a really effective "death ray," more deadly than gamma radiation, or one that could explode nuclear missiles from a distance. It may be still more fanciful to suggest that even better thermo-nuclear devices can be developed—for instance, from helium or from still another hydrogen isotope. In such a case—and if the secret could be kept—some nation might be tempted to go to war in the belief that the balance of nuclear potential had been disturbed in its favour.

I think, too, that it is dangerous to assume that any such balance actually exists, and the Russians, who seem to have an advantage at present in the range and guidance of their inter-continental ballistic missiles, may not agree.

Even so, the necessity for research remains, on the chance that something still more formidable will emerge to give one side an overwhelming, if temporary, advantage. To neglect its civil defence a nation invites attack, and opportunity is an important element in power politics.

(Continued on page 17)

About the Author

THE author of this article was born in 1875 and is the only survivor of seven brothers, the sons of an Army Chaplain who was a celebrated Sanskrit scholar.

He was commissioned into the Royal Engineers, through the R.M.A., Woolwich, in 1894, and his subsequent career provides an example of the versatility for which members of his Corps are noted.

His foreign service includes tours in the Gambia, Sierra Leone (twice), the Gold Coast and Nigeria; South Africa, the West Indies, Ceylon and India. He has built barracks and coast defenses at home and in Sierra Leone and Ceylon; and he commanded a Field Squadron in the Cavalry Division in the Boer War and a Field Company in the 1st World War, before undertaking gas operations. In the Boer War he was the first to use telephotography in military reconnaissance and was also appointed a Staff Captain for Intelligence. During Lord Lugard's Kano, Sokoto, campaign in Nigeria in 1902, when the member responsible for astronomical work of the Anglo-French Boundary Commission, Niger to Lake Chad, he took a fleeting opportunity to make prisoner the fugitive Emir of Kano. On this occasion he was accompanied only by a Hausa soldier and his personal native servant, and covered 175 miles in a non-stop ride lasting 3 days and 2 nights.

He was engaged for 5 years on the Ordnance Survey of Scotland, was once put in charge of a propaganda department, and at the end of the 1st World War was sent to Simla for consultation on the future training in chemical warfare of the Indian Army; and after studying frontier warfare in the Afghanistan and Waziristan campaigns he had the probably unique experience of being invited to lecture privately to the Viceroy of India and his full Executive Council.

His last appointment was Chief Engineer of the Aldershot Command, a post formerly earmarked for the Engineer-in-Chief of the next Expeditionary Force.

While still a junior regimental Major he was given army brevets of Lieutenant-Colonel and Colonel and held two separate appointments as Brigadier-General. Of the 17 ribbons he is entitled to wear, seven represent campaign medals and three others "immediate" awards in the field; and besides his British distinctions he has been decorated by the French, Belgian, Italian and the United States Governments. He was Colonel-Commandant R.E. for 8 years and the Representative Colonel-Commandant in 1944, and was A.D.C. to H.M. King George V for 3 years.

In his younger days he was a successful big game hunter and an all-around athlete and a hockey International, with the Olympic medal for 1908. After retiring in 1930, he became a skilled cabinetmaker and joined (and is still on) the Boards of the John Oakey group of abrasive manufacturers. He has published two books, "Gas. The Story of the Special Brigade" and "Commonsense and A.R.P.", the latter after acting as consultant to more than 150 of the most important factories and business concerns in England and Scotland. He joined the Home Guard in the 2nd World War.

General and Mrs. Foulkes celebrated the 57th anniversary of their wedding a few weeks ago, and their three sons are all making successful careers, the eldest being the present Engineer-in-Chief at the War Office, with the rank of Major-General, who recently toured Army Engineer Establishments in the United States.

Port Hueneme Controls Group 68 Chemicals For Naval Supply

The purchase of chemicals and chemical products at the Yards and Docks Supply Office is confined to material in Federal Stock Classification Group 68. There are five classes in this group; namely, 6810 - Chemicals, 6820 - Dyes, 6830 - Gases, Compressed and Liquefied, 6840 - Pest Control Agents and Disinfectants, and 6850 - Miscellaneous Chemical Supplies. Group 68 excludes Medical chemicals which are generally included in class 6505 - Drugs, Biologicals and Official Reagents. Also excluded from Group 68 are liquid chemicals designed exclusively for use as propellant fuels and oxidizers, which are in class 9135. A further general description of material in each of the five classes within FSC Group 68 is shown as follows:

6810 - Chemicals. This class includes such items as acids, solvents, water softening and bleaching compounds, metal-treatment chemicals, cleaning and laundry supplies, reagents, etc.

6820 - Dyes. This class includes gas protective clothing dyes.

6830 - Gases, Compressed and Liquefied. This class includes the entire range of compressed and liquefied gases with the exception of military chemical gases, medical gases and fuel gases.

6840 - Pest Control Agents and Disinfectants. Included in this class are such items as insect repellents, fungicides, insecticides, rodenticides and weed killers. Personal deodorants are not included in this class.

6850 - Miscellaneous Chemical Specialties. This class includes a wide variety of items such as antifogging compounds, wetting agents, etching and fountain solution for lithographing, and antifreeze.

YDSO centrally controls the majority of the items within FSC Group 68 which are used by the Navy. Most of these items are centrally purchased by YDSO. However, some of the items in this category are centrally purchased by designated Single Department Procurement Activities. For example, a number of pest control items are purchased by the Navy Purchasing Office, New York, and antifreeze is purchased by the Army Raritan Arsenal, New Jersey. The remaining items within FSC Group 68 having Navy interest meet the established criteria for local control and are therefore purchased and controlled by Navy stock points or consumer activities. Applicable information regarding the number of items in each category by class and estimated annual requirements in dollars is reflected by the following table:

	Items Centrally Controlled by YDSO		Items locally purchased and managed by Navy stock points or consumer activities	
Class	Number of Items	Estimated Annual Requirements	Number of Items	Estimated Annual Requirements
6810	122	1,294,800	50	Unavailable
6820	6	Nil	1	Unavailable
6830	5	3,662,200	54	2,422,100
6840	38	427,100	4	Unavailable
6850	68	796,800	23	Unavailable

The above dollar value estimates are based on past repetitive demands. Unusual or one-time requirements are not included in the repetitive demand figures as they are not normally used in forecasting stocking objectives. However, as a matter of interest, the dollar value of one-time requirements has been relatively small during recent months.

Assets in Class 6820 - Dyes are held as mobilization reserve stock, which accounts for the lack of repetitive demand issues. Consequently, the central purchase of chemicals and chemical products by means of formally advertised contracts is primarily concerned with material in Classes 6810, 6840, and 6850. Although 228 separate stock numbered items in these three classes ac-

count for an estimated annual demand value of $2,518,700, only six per cent of the items account for over half of this amount.

The purchase and inventory management of compressed and liquefied gases by Navy stock points and consumer activities is a matter of considerable importance and interest to this office and the Navy as a whole. The Naval activities involved purchase their requirements of gases, except helium, in Government-furnished cylinders from local suppliers under General Service Administration contracts. However, small annual requirements not exceeding $2,500 value (each type gas for one destination) may be obtained by Navy field activities under local purchase orders.

The story on helium is rather unique because of its limited supply and special uses. Consequently, the purchase and inventory management functions require a great deal of attention. More specifically, helium is purchased by YDSO from the Bureau of Mines under an annual indefinite quantity type contract, and inventory management functions are shared between YDSO and stocking points. Monthly orders under the contract are placed by YDSO, based on estimated requirements submitted by storage points. The total cost of purchases this year is expected to amount to about 3.66 millions of dollars. Actually, about two-thirds of this amount is for ultimate use by governmental agencies other than the Navy such as the Air Force, National Aeronautics and Space Administration and government contractors. In this connection, YDSO arranges to have a large portion of these requirements shipped directly from processing plants to requiring agencies. Bulk helium is stored at several Naval activities from which issues are made, including the filling of cylinders to meet the demands of stocking and consumer activities.

There is a wide range of differences between items in FSC Group 68 such as item characteristics, source of supply, value of total annual requirements, military worth, demand pattern, transportation and storage considerations, etc. For example, 15 of the best selling items in FSC Group 68, which are centrally purchased and/or controlled by YDSO, account for 56 per cent of total dollar requirements, excluding helium. These items are identified below for information purposes:

Federal Stock Number	Description	Estimated Annual Requirements
9YF 6810-184-4800	Trichloroethylene, Technical (55-gal. drum)	$457,300
9YF 6850-243-1992	Antifreeze	216,600
9YM 6850-637-6142	Scale Removing Compound	102,600
9YF 6840-254-8770	Insecticide, DDT-Allethrin	84,100
9YF 6850-264-6571	Desiccant, Activated (300 50-gm bags per drum)	62,200
9YF 6840-246-6438	Deodorant, Toilet	54,900
9YF 6810-264-3939	Chromium Trioxide, Technical	53,800
9YF 6850-264-6572	Desiccant, Activated (150 50-gm bags per drum)	52,300
9YF 6810-184-4794	Trichloroethylene, Technical (5-gal. drum)	49,400
9YM 6850-577-4575	Cleaning Compound, Solvent	48,300
9YF 6810-264-9025	Sodium Hydroxide, Technical	48,100
9YF 6810-664-7487	Sodium Phosphate, Tribasic, Anhydrons, Technical	47,400
9YM 6810-664-0388	Trichloroethane, Technical (5-gal. drum)	46,700
9YF 6810-275-6011	Methanol Reagent	43,500
9YF 6850-255-0429	Boiler Compound	40,500

Manufacturers, distributors, and regular dealers are encouraged to bid on YDSO purchases of chemicals and chemical products. Suppliers who desire to bid on YDSO requirements may contact the YDSO Purchase Division, Port Hueneme, California (Codes PSB). Once on a bid list, suppliers are automatically notified when there is a requirement for an item. Every effort is made to maintain a current list of interested bidders in order to obtain maximum competition.

Defense Supply Plans Study Of Chemicals In Group 68

The Defense Supply Agency can be described with over-simplicity as a single manager for single managers.

Savings to the government, which are estimated to be considerable, will accrue as Lieutenant General A. T. McNamara formulates the ground rules for logistics management.

It is apparent to management experts who deal with such problems that uniform standards for paperwork as well as specifications, more efficient uses of personnel, elimination of duplication, and full use of warehousing facilities in a common supply system for the four services will result in savings.

The theory was put into practice with the single manager for a single commodity, and it worked. Now the Defense Supply Agency can interchange or integrate the supply effort in the most economical fashion, like single manager parcelling out the various jobs among his experts.

This newly formed agency assumed the functions of the seven then-existing single commodity managers, and is taking over the supply functions for about half or 450,000 electronic and electrical materiel items now in the Defense Establishment. Studies are also contemplated for machine tools, chemical supplies and aeronautical spare parts.

Whether chemical supplies will fit into the Defense Supply Agency is a good question. The dollar figure being bruited about is fifty million in inventory value for chemical supplies that could wind up for management purposes in the Defense Supply Agency.

This fifty-million-dollar inventory represents only five classes of chemicals in Federal Supply Group 68. Included are: naphtha solvents, water softening compounds, tanning materials, dextrines and starches, inedible gelatins, acetones, dyes including household tints, compressed and liquefied gases other than military chemical gases, medicinal gases, and fuel gases; insect repellents, fungicides, insecticides, rodenticides, weed killers, antifogging compounds, wetting agents, etching and fountain solutions for lithographing, and antifreeze.

It is also estimated that there is another fifty-million-dollar inventory supply in Class 8120, Gas Cylinders.

The group 68 inventory has nothing to do with the chemical weapons systems and protective devices developed by the Army Chemical Corps. Each military service retains control and development of its assigned weapons system.

By the same token, the U.S. Air Force will retain control and development of various chemical products such as rocket fuels, etc., that are to be used in Air Force missiles. The same situation is true for the Navy and the other branches within the Army.

The single managers for petroleum supplies, medical supplies, foods, and paints have already joined the Defense Supply Agency.

A study to determine what chemicals excluding those that are parts of weapons systems and those already in the Defense Supply Agency could be accomplished by memorandum, in all probability, according to members of the Armed Forces Supply Support Center, now part of the Defense Supply Agency.

The Armed Forces Supply Support Center has made the staff studies and recommendations for the establishment of the single manager assignments, and their most recent study for the management of selected electrical and electronic materiel has without doubt set the pattern for logistics within the Defense Department.

There are some 900,000 electronic items in the military supply system but only about half, or 450,000, were adopted by the Defense Supply Agency. This means, then, the other half which remained with the four services were parts of weapons systems or critical to the operation of such systems, and for that reason remained with the individual service.

This same principle would apply to chemical supplies in Federal Group 68. If one of the Services found any item of supply necessary to a weapons system or to the maintenance of the system then such purchases and handling would remain with that Service.

There are, however, probably only a few items in Federal Group 68 that will serve in a weapons system concept.

Deputy Assistant Secretary of Defense Paul H. Riley is of the opinion that the study of chemicals will deal with supplies in Federal Group 68.

There is a chance, too, that soaps and detergents may be dropped from Military Procurement, and purchases authorized under General Services Administration contracts instead. For the most part, these supplies are now obtained in local markets and GSA contracts would serve this function very well.

Chesapeake Group Tours Martin Plant

The Chesapeake Chapter of the Armed Forces Chemical Association were recent guests of the Martin Company of Baltimore. A large group of members and their wives, representing the Army Chemical Corps and Baltimore industries were given this opportunity to visit the Martin-Baltimore facilities.

The Chesapeake Chapter of the AFCA has its headquarters in the Baltimore-Edgewood area of Maryland. The tour was a part of the Association's program of establishing and improving relations between industry and the Chemical Corps. The group believes that associations developed through tours such as this will lead to a mutual understanding of problems and closer working arrangements leading to a more efficient, productive Chemical Corps. In addition to better working arrangements, the group supports civilian agencies and individuals in promoting new developments in chemistry, in the allied sciences and in engineering applications designed to increase the efficiency and effectiveness of the services in chemical research and devlopment.

During the recent tour the group saw a variety of intricate production work for the Army, Navy and Air Force missile systems in production at the Martin plant. This work is related to such systems as Pershing, Dyna-Soar, Titan, Mace, and Bullpup.

Following the plant tour and a dinner meeting, AFCA members heard a lecture by Dr. Charles E. Crompton, Director of Nuclear Chemistry at Martin. Dr. Crompton's subject concerned recent developments and problems related to nuclear power units. Among those attending the meeting were: Brig. Gen. Lloyd E. Fellenz, Commanding General of the Army Chemical Center and the Chemical Corps Material Command along with members of his staff concerned with Research and Development, Engineering, and Procurement and Supply; Mr. Ovid E. Roberts, Secretary of the AFCA; and members from Olin-Matheson Chemical Corporation, Diamond Alkali Company, Aircraft Armaments Inc., the Glidden Company including the PEMCO Division, and the Martin Company.

John H. Fonner, of the Diamond Alkali Company and President of the Chesapeake Chapter, announced completion of plans for the January meeting to be held at the Westinghouse Electric Corporation. In keeping with the organizations program another future meeting will be held at the Bethlehem Steel Company.

New York Chapter Elects Two New Directors

Major General William M. Creasy, U.S.A. (Ret.), Vice President of the Lummus Company and Stanley A. Mattison, Public Relations Director of Hooker Chemical Corporation, have been elected directors of the New York Chapter of the Armed Forces Chemical Association, Robert J. Milano, Chapter President, announced. The other directors are: Simon Askin, Heyden Newport Chemical Corporation, Col. Evan H. Lewis, First U.S. Army, W. Ward Jackson, Commercial Solvents Corporation, General A. C. McAuliffe, U.S.A. (Ret.), American Cyanamid, and James Sheridan, Allied Chemical Corporation.

Detrick Elects New Officers

A new slate of officers was elected by the Fort Detrick Chapter when Major Eugene Cronin, President of the Chapter, suffered a severe heart attack and was unable to complete his term of office. Those elected to serve were: Mr. Everett Hanel, Jr., President; Capt. John C. Kirsch, Cmcl., 1st Vice President; Charles R. Baldwin, 2nd Vice President; David R. Spiner, Secretary-Treasurer.

Army Chemical, Ordnance Receive Safety Awards

The Army's Chemical and Ordnance Corps received 1st and 2nd place awards for their outstanding records in the field of safety administration.

Lieutenant General R. W. Colglazier, Jr., the Army's Deputy Chief of Staff for Logistics, presented a gold plaque, symbol of the Award of Honor for Safety, to Major General Marshall Stubbs, Chief Chemical Officer.

The second place silver plaque, the Award of Merit for Safety, was presented to Lieutenant General J. H. Hinrichs, the Chief of Ordnance.

Chemical and Ordnance received the awards in competition with the other five Army Technical Services. Similar awards are made to the two outstanding Army Areas in the Continental U. S. and major oversea commands.

Recipients of the safety awards are selected primarily on the basis of improvement over the preceding year in three important safety categories: number of accidents per capita, number of injuries per capita, and the cost of each accident. Command program leadership and direction are also considered, and all factors are given a certain number of points in determining the winners.

Lt. Gen. John H. Hinrichs, Chief of Ordnance, U.S. Army, discusses the temporary stockpiling of ammo in Berlin's Grunewald with Lt. Col. J. D. Polley, III, and Capt. R. B. Good.

An American patrol on the Treptower Strasse draws little attention from the East Germany Army troops alongside the street.

These are the men of Michael Army Airfield, Dugway's aviation arm. Front row, left to right, CWO Ellis E. Brabee, Capt. Harvey F. Miller, Capt. Richard H. Potts, Capt. Donald G. Curry, 1st Lt. Donald M. Hinrichs. 2nd row, left to right, Sgt. Johnny L. Ortiz, Sgt. Arnold J. McGraw, S/Sgt. William J. Herie, Sp 4 Stephen G. Rowley, Sp 4 Joseph F. Quintana, PFC Lloyd F. Cornhue, PFC Johnny L. Campbell, PFC Douglas L. Olsen, Sp 4 Herbert R. Castle, Sp 5 Fred W. Talbot. 3rd row, left to right, PFC James F. Cox, PFC Jeronimo F. Quintana, SFC Thomas G. Stewart, SFC William H. Reiser.

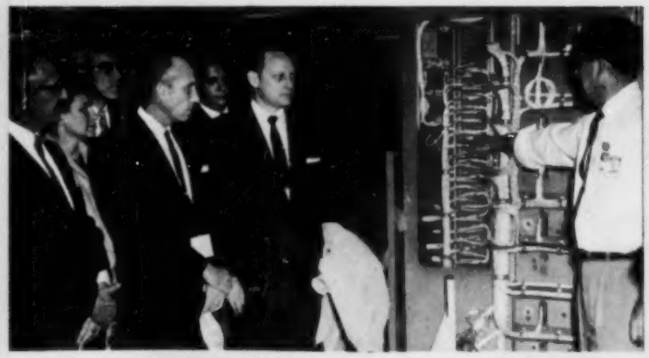
Pfc. Aubrey L. Hyatt (El Campo, Texas) and Sp4 Jose C. Quichocho (Yona, Guam) members of Co. B, 2nd Battle Group, 6th Infantry, take part in training exercises in Berlin.

The winners in the annual Rocky Mountain Arsenal Fall Handicap Golf Tournament are shown with their trophies which were presented by Colonel Charles H. McNary, Commanding Officer of the Arsenal. Left to right, the winners are Lt. Colonel Albert H. Rock, Deputy Commander, fifth place winner; SFC Robert T. Yoshioka, third place winner; Mr. Charles H. Ramsey, first place winner and medalist winner; Colonel McNary, Arsenal Commander, who presented the trophies; Captain Artie L. Angelo, second place winner; and M/Sgt. Anthony Pondiccio, fourth place winner.

Colonel Glover S. Johns, Jr., CO of the 1st Battle Group, 18th Inf., 8th Inf. Div., talks with Brig. Gen. Frederick O. Hartel, CG, Berlin Command.

The 1st Battle Group, 18th Inf., clears the last Allied barrier at Helmstedt before entering the East Zone bound for Berlin.

West Berliners cheer and wave as soldiers of the 1st Battle Group, 18th Inf., pass the bombed ruins of Kaiser Wilhelm Church. The group was led into the city by Col. Glover S. Johns, Jr.



AFCA MEMBERS INSPECT the interior wiring of section of the Pershing missile fire control system at the Martin Co. John T. Brown, a foreman in the electronics division of the company explains the system to (l-r): Ashler Z. Cohen, group secretary; Brig. Gen. Lloyd E. Fellenz, Commanding General of the Army Chemical Center and Materiel Command; and Dr. Robert L. Shively, vice president of the organization.

Lt. Col. Khalil Ibrahin Hussein, OCCm10 Iraq Army, looks at measuring blocks shown him by Earl Smith, Chief of the Maintenance Division, Army Chemical Center.

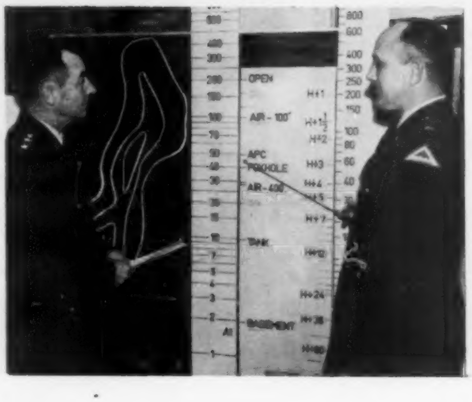
Captain Rebecca L. Bennett is promoted to Major with ceremony as General Stubbs and Lt. Col. John Moran pin on her leaves while Mrs. William Howard Bennett, her mother, looks on.

AFCA's WILMINGTON CHAPTER made a recent visit to ACC. The group toured the various agencies and facilities on post. Among the items inspected was this positive ion accelerator used in the production of neutrons. Explaining the process is Mr. David Rigotti of the Nuclear Defense Laboratory.

Dr. Koyoshi Higuchi, medical bacteriology division at Fort Detrick, was awarded the Army Research and Study Fellowship. He will spend one year in Japan at the Department of Medical Chemistry at Kyoto University. He is a native of Los Angeles and received his Ph.D. in biochemistry at the University of Wisconsin.

HANDS ACROSS THE SEA— Say Sp4 Traversy Fernand, Montreal, Canada, Les mains a travers le mond e; Pvt. Bock Chan,, Kwontung, China, Shu Lin Sai Gai; Sp4 Jose Rojas, Lima, Peru, Las Manos A Traves Del Mundo; PFC Horst Henschel, Kutzdorf, Germany, Hande Uber Die Welt; PFC James Heselton, Barnes, England, Hands across the world; anl Sp4 Bill Pico, Mexicali, Mexico, Alos Alcanzes Del Mundo. These six soldiers, stationed at Dugway Proving Ground, Utah, observe this anniversary of the "United Nations" by giving a pledge of "International Unity".

ZAMA (HQ., U.S. ARMY JAPAN)— Dr. Kenzo Okabe (Right) Ph.D., Japanese employee of the 406th Medical General Laboratory, U.S. Army Medical Command Japan, shows the operations of a binary scaler counting unit in the Biophysic Section of the laboratory during the recent Camp Zama tour of four chemical experts of the Japanese Ground Self-Defense Forces. From left to right are Col. Kazumi Fujii, Commandant, GSDF Chemical School; Col. Hideo Toyama, Chief, GSO Chemical Section; and Dr. Okabe.



MANNHEIM, Germany—Maj. Gen. A. J. Adams, Seventh U.S. Army Support Command CG, examines a training aid-size model of the Fallout Decay and Shielding Estimator, used by its inventor, Major J. H. McNally, in radioactive fallout instruction in all Support Command CBR courses. In General Adams' hands is a small-size set of the estimators used by individual students.

WARFARE IN 1915

(Continued from page 4)

As might be imagined, I was faced with many difficulties in procedure, some of them amusing. For instance, there was an indignant protest from the Quartermaster-General's branch when my request for 300 watches (with which to synchronise the commencement of the gas discharge) was stated to be unprecedented. However, General Robertson, French's Chief of Staff, supported me whole-heartedly and issued peremptory orders for first priority to be given for everything I demanded.

Gas cylinders trickled across the Channel very slowly, but other circumstances caused a postponement of our offensive, from July to August, and finally, from September 15th when the wind was very favourable, to the 25th, when it was not. At this last date the organisation and instruction of the "Special Companies" had been almost completed, and a highly successful demonstration of a cloud attack in our training area, attended by every senior commander in the Expeditionary Force, had inspired confidence in the gas and in the technique adopted. For the attack on the 25th, 5,500 cylnders containing 150 tons of chlorine were installed and protected with sandbags along a front of 24 and one-half miles, together with 46,000 phosphorous smoke candles and bombs that had been improvised in order to prolong the discharge of gas with intervals of smoke, to simulate gas on fronts not assaulted, to supply the deficiency of cylinders and to conceal the approach of our troops. As an example of the pressure during the last few days, the final batch of cylinders to reach us left Runcorn by special train on the 22nd September, arrived at Boulogne on the 24th and was put into lorries and carried into the trenches the same night.

I had 60 officers in action, of whom only one, Captain Eddis R.E., was a regular soldier, and 1400 men recruited mostly straight from civil life, and who were now about to come under fire for the first time: one of them, a bespectacled chemist's assistant, was awarded the Victoria Cross for gallantry on September 25th.

My readers may like to be reminded of the result of all this improvised effort. Briefly, the gas attack was much more successful than was generally supposed. The cylinder installation in 400 emplacements by infantry carrying-parties had been accomplished in complete secrecy and without a hitch, but infantry commanders had refused categorically to vacate their front line trenches, as I had planned, to avoid exposing them to gas leakages and to the inevitable artillery bombardment that the discharge would attract. It was considered unthinkable in those days to abandon a trench for even half an hour, though it became common practice in gas attacks later in the war.

I had circulated to everyone concerned the conditions in which gas could be discharged safely—within certain limits as to the direction of the wind in relation to the line of trenches, and with a minimum velocity of 4 to 6 miles per hour.

I controlled the operation from the Army Commander's (Sir Douglas Haig) advanced headquarters at Hinges. There I had a detailed trench map of the whole front laid out on a trestle table, and on it were marked with flag pins the locations of every gas officer in charge of a section, each of whom sent me in code, every hour of the night, a report of the direction and velocity of the wind in his area. The Signal Corps had been ordered to give first priority to these messages, and as each one came in the appropriate flag was pointed in the direction of the wind, as reported, and the velocity was pencilled on it. General Butler, Haig's Chief of Staff, came in to examine the map at frequent intervals during the night and he was aware of the conditions in the front line trenches up to almost the last moment before the attack began. The wind was light and variable everywhere and it did not conform to my minimum requirements, but Butler and Haig decided, after considerable hesitation, that the operation was to proceed according to the arranged schedule.

The first aeroplane reports that came in at dawn were to the effect that a dense gas cloud was rolling steadily toward the German lines. Some of my officers had refused, as instructed by me, to open their cylinders if the conditions were such as to endanger our own troops, but when this was reported they were over-ruled, the decision coming, it was said, from the Army Commander himself.

The fact was that Sir Douglas had been ordered to attack at a definite time and date, and on a front not of his own choice, but one indicated by the requirement of the French on our right flank. He felt that, without reinforcements from our new armies—which was imminent—and with inadequate artillery preparation—in the absence of high explosive shells—his attack would fail unless the gas discharge was successful, and he was willing to take a risk.

Perhaps he was justified. As it happened, the Germans were taken completely by surprise and they were demoralised when they found that their masks gave them little or no protection: this we

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had expected, from examination of those found on men previously taken prisoner.

Five of the six Divisions that took part in the main attack captured the German trench systems without much difficulty, and only the 2nd (in which I had served) failed to advance on our extreme left, opposite La Basse, through some of its elements entered the German front line. All the Commanders concerned were convinced that, with very little damage having been done to the barbed wire entanglements by the artillery bombardment, no advance would have been possible anywhere without the gas. The 9th Division, next in line to the 2nd, walked over the famous Hohenzollern Redoubt with hardly any loss and advanced for a mile in the first rush, and similar progress was made by the 7th Division further south. On our extreme right the gas attack was an unqualified success and the whole of the IV Corps, consisting of the 1st, 15th and 47th Divisions, captured the first two German lines in 15 minutes. and then took the village of Loos and advanced a mile beyond it, though much of this ground, including the Hohenzollern Redoubt, was lost in the next few days in counter-attacks, mainly through the superiority of the German hand grenades. This Redoubt was taken again, very easily, after another gas attack on October 13th, but was lost a second time by counter-attack. 18 German guns were captured on the 25th and more than 3,000 prisoners were taken.

In his official dispatch Sir John French wrote "our gas attack met with marked success and produced a demoralising effect in some of the opposing units, of which ample evidence was forthcoming in the captured trenches". And the German communique of the 25th September contained these words: "Even this retirement was not the result of the English Commander's abilities, but was the consequence of a successful surprise attack with intoxicating gases."

Our first year of the gas war had been a period of improvisation and experiment, and all developments were very slow. It was only in July 1916, that we were able to use phosgene in our cloud attacks, though its value had been recognised and an urgent demand made for it a year earlier. Gas fillings for shells, projectors and the 4" Stokes mortar were used for the first time in April 1917, and mustard gas only became available in September 1918—fourteen months after the Germans used it.

At a meeting of a chemical committee in the 2nd World War, at which I was present, a new rifled mortar was being discussed which the Ordnance Board had pronounced unsafe, and I was asked what factor of safety I considered sufficient in 1915. I replied that we never used one, though we took care not to endanger our own troops. As an example of the expedients to which we resorted I might mention the beginnings of what became known as the Livens projector. For lack of anything that looked more like a mortar Captain Livens used ordinary petrol drums, well tamped into the ground and set at an angle of 45°. The bomb consisted of a slightly smaller drum which contained various fillings, and the amount of the cordite propellant charge varied with the range. At one demonstration at which a number of senior commanders were present, he fired a salvo of 20 of these drums filled with high explosive, to discover their effect on a barbed wire entanglement. After the discharge, when the spectators had almost reached the target area to see what damage had been done, Livens noticed that one of the drums containing 50 lbs. of TNT had failed to explode, and, shouting "Run for it", he led an undignified retreat. He may recall this as the highlight of his military career—the occasion when he barked out an order to an Army Commander (Gough), and was promptly obeyed.

Manufacturers Figure On Women's Figure

Playtex, Peter Pan and Maidenform can become more familiar names in the chemical industry now that chemicals are being used in ladies foundation garments and the bra manufacturers have just had the biggest year in their history. The manufacturers have boosted their ad budgets and are paying attention to the youngest of teen agers and the European market where the ladies are not as bra conscious as woman in the U.S.

Died

Raymond S. Bailleul former Secretary-Treasurer of the Chesapeake Chapter. At the time of his death, he was employed in the Headquarters of the Chemical Corps Material Command.

Lt. Col. Willis E. Semple, executive officer of the 15th Chemical Group of the U. S. Forces in Germany, of a heart attack. He was a native of Lenoir, North Carolina and a veteran of 20 years service with action in both WWII and Korea. He is survived by his wife and three children, Linda, 13, Rick 12 and Terry 2.

WARFARE NOW

(Continued from page 6)

Besides, the knowledge gained from this type of research is likely to be of benefit to human welfare in its peaceful applications.

(3) A war between any of the Great Powers, starting with conventional weapons, seems almost certain to develop, sooner or later, into nuclear rocketry, and this is almost inevitable if nuclear "tactical" warheads are used with bombs, ground missiles or shells, as seems to have been decided, because differentiation between tactical and nuclear weapons is not practicable. In such an event all other weapons, chemical, bacteriological, and even high explosives, would be futile in comparison.

(4) But even if the war could be confined by mutual restraint to conventional weapons only, its probable character would be such that no worth-while targets would be presented for this admittedly formidable weapon.

I imagine that in a future war it will be impossible, without air superiority, and because of the vulnerability of their communications, to maintain armies overseas comparable in numbers and equipment with those engaged in the two first World Wars. Mine-fields will constitute a more formidable obstacle than machine guns and barbed wire, and it may well be that the supremacy established by armoured vehicles and low-flying aircraft in the last war will be challenged through the improvement that has taken place in missiles. Self-contained ground forces will be far more mobile and dispersed than ever before, and they will move for the purpose of concentration under cover of darkness, so that when marked down for attack they will not be found where they were last located a few hours earlier.

To summarize the reasons that incline me to the view that, in spite of its cheapness, chemical warfare has had its day:

(1) Because of the apparent existence of a balance in nuclear equipment between East and West, mutual fear has created a deadlock, and no chemical or other weapon will be used unless this balance is disturbed.

(2) The abstention from the employment of nerve gases in the 2nd World War appears to suggest that a similar deadlock has been reached in regard to chemical weapons.

(3) If war breaks out inadvertently with conventional weapons it seems almost certain to develop, sooner or later, into all-out nuclear conflict; in which case all other weapons would be futile in comparison.

(4) Finally, if the conflict could be confined to conventional weapons, ground forces would be so mobile and dispersed that they would offer no targets for the employment of chemicals.

As for attacks on civil populations, cities have been bombed with high explosives almost to the verge of obliteration, but, apart from the casualties inflicted and interference with armament production, this policy resulted in no public intimidation, nor did it affect the leaders in their determination to continue hostilities, though the bombing of Rotterdam probably hastened the surrender of Holland. And, in my opinion, no gas would have been more successful.

But with nuclear weapons the damage would be catastrophic and one can only speculate which side would have to call a halt to the senseless devastation. It might well happen for a nation's armed forces, even when victorious in the field, to have less influence in enforcing its policy than the demands of the situation on the home front: especially in the case of Russia, where revolutionary tendencies are endemic. In the confusion caused by the breakdown of communications and central control, half a dozen satellite countries, as well as a predatory neighbor in the Far East, and, perhaps, some of her own provinces, might be expected to welcome such an opportunity to terminate the present regime.

Paint's Importance in the Progress Of Naval Aviation

BY M. B. PFEIFFER, A. M. MALLEY
and S. KAPLAN
Bureau of Naval Weapons

* *

★ High Visibility Paints
★ Heat Resistant Aircraft Finish
★ Thermal Reflecting Paints
★ Rain-Erosion Resistance
★ Improved Protective Finishes
★ Properties of Films
★ Improved Inhibitive Pigments
★ Two-Coat Paint System
★ High Temperature Paint
★ Other Investigations

* *

ORGANIC protective coatings have consistently demonstrated an important role in U.S. Naval aircraft engineering since the beginning of aviation. Fifty years ago airplanes constructed of wood, baling wire and canvas, with a few bolts and sheet metal fittings, were reasonably well protected from deterioration by organic paint finishes primarily developed for ships.

Their use endured until the Close of World War I. In the meantime, nitrate dope was introduced as an agent to give cotton fabrics the proper tautening characteristics. Then, in the search for optimum protection of Naval aircraft, experiments with spar varnish and acetate dope were found to improve the moisture resistance in wood, and the fire resistance in fabric.

With the growing use of weight-saving aluminum in airframes, the Navy's Bureau of Aeronautics (now the Bureau of Naval Weapons) commenced searching for promising finishing materials for metal. Red oxide primers, Navy gray enamels, and aluminum pigmented dope were adopted as standard. In the 1930s, progress in this endeavor was marked by the replacement of red oxide by zinc chromate primers. This was considered a distinct aeronautical achievement as it practically eliminated corrosion of aluminum—a major factor in the service life of airplanes. Navy gray enamel eventually gave way to lacquer and other types of enamel. Dopes became primarily the fire-resistant cellulose acetate butyrate type when the Navy became concerned over the flammability of cellulose nitrate dope on aircraft used aboard carriers.

With improvements in durability of lacquers, these were adopted in World War II as standard in the interest of accelerated production. The net result was that although a shortage of specified solvents was evident, there was no delay in the Navy's program due to lack of supply of organic finishes. Furthermore, Navy records indicate that these coatings contributed immeasurably to the 90-95 per cent availability and the superior performance of Fleet aircraft in combat areas by maintaining a ready condition under difficult climatic conditions with the barest minimum of maintenance.

At the end of World War II, with the introduction of jet aircraft, paint adhesion problems were encountered on practically all aircraft models, regardless of Navy or industry application. The higher operating altitudes and speeds apparently subjected the paint to greater thermal shock and air stresses which resulted in failure at the weakest link, namely, adhesion at the metal-paint interface.

The Navy was engaged in a program to improve the adhesion of the finish, but serious consideration was given to removing finishes from Navy aircraft. In fact, several hundred unpainted Navy aircraft were purposely produced at this time and operated by the Fleet to determine the maintainability of such aircraft. After approximately six months of carrier service, Fleet Commands made strong representations, requesting that paint be reinstated as a requirement for Navy aircraft. It was found that operation ashore was practicable without paint, but pitting-corrosion developed in a short time once the aircraft were placed aboard carriers.

Fortunately, the Navy had been service testing "wash primers" as an adhesion promoter for the aircraft finish and was ready to introduce the requirement for use of pre-treatment coatings (commonly referred to as "wash primers"). At first, Specification MIL-C-15328 was called out, but this was later replaced by Specification MIL-C-8514 because of the greater smoothness of the resultant finishes. At this point, Navy aircraft employed a standard exterior finish of MIL-C-

8514 pre-treatment coating plus MIL-P-8585 zinc chromate primer plus MIL-L-7178 or MIL-L-6805 nitrocellulose lacquer.

This finish system remained standard until the introduction of turbo-engines with higher operating temperatures, employing MIL-L-7808 diester-oil type lubricants, which are excellent paint strippers. It was quickly found that the oil mist vented from the engine breather holes attacked the aircraft finish, producing a soft "mush" with the paint. Fortunately, other finishes were being developed under an earlier long-range project at the Naval Air Material Center, Aeronautical Materials Laboratory, at Philadelphia, as part of the integrated Bureau of Naval Weapons (Bureau of Aeronautics) paint development program. A preliminary examination indicated that several had the required diester oil resistance.

The finish system which was most advanced at that time, and which fitted best into the available production facilities was an acrylic-nitrocellulose lacquer system. An immediate change-over was effected to this new system, which comprised the same MIL-C-8514 wash primer, a new MIL-P-7962 (nitrocellulose alkyd) zinc chromate primer, and MIL-L-19537 or MIL-L-19538 acrylic-nitrocellulose lacquer. This has been the standard Navy aircraft finish for the past several years.

During this period, research and development in the fields of test methods, special finishes for high visibility, camouflage, heat resistance, rain-erosion resistance, and generally improved performance have been supported by the Bureau of Naval Weapons (Bureau of Aeronautics) at private contractors' and university laboratories, and this Bureau's Aeronautical Materials Laboratory at the Naval Air Material Center.

It should be pointed out that many of the problems encountered by the Bureau are investigated at the Naval Air Material Center. The Naval Air Material Center works in cooperation with and simultaneously with industry, particularly when industry has been unable to pioneer the required development because of the competition afforded by commercial projects or the unavailability of sufficiently trained scientific personnel or specialized test equipment. It is then the job of the Naval Air Material Center to tackle the task and establish the fundamental research required for its successful furtherance.

A few examples of the many research studies on aircraft finishes which have been instituted under the Bureau of Naval Weapons (Bureau of Aeronautics) research and development program are discussed below:

1. High Visibility Paints.

Paint has played an important role in the evolutionary process which has materially increased the margin of mechanical safety in high-performance aircraft in the last decade. By providing significant help in preventing mid-air collisions, the development of high-visibility color under a Bureau of Naval Weapons program has added a new dimension in safety to Navy aircraft.

Since the Navy began using the now familiar red-orange fluorescent paints, statistics on air collisions have indicated a definite decline in accidents directly attributable to easier sighting of close flying aircraft. Prior to this, the Navy employed an orange-yellow color on all of its trainers as the standard color.

The first serious color experimentations were made back in the early 1940s at the Air Crew Equipment Laboratory of the Naval Air Material Center, Philadelphia, upon request of the old Bureau of Aeronautics. Their object was to render airplanes more conspicuous in flight through use of brilliant exterior finishes. A blue and silver color scheme was selected as most effective, but was not put into use, as emphasis was changed to camouflage colors upon the approach of World War II.

New hazards for Naval aviation were created with the advent of supersonic jets in the early 1950s. The time had come for a renewed search for improved visibility of Naval aircraft to reduce the constantly growing danger of mid-air collisions. The Naval Research Laboratory scientists, in collaboration with industry, came up with a paint mixture using the phenomenon of fluorescence for aircraft coatings which were effective in twilight and low-visibility flying. Fluorescent paints emit two to three times as much color as the brightest non-fluorescents. In-flight tests of color schemes under poor visibility conditions were resumed at the Naval Air Stations in Corpus Christi, Texas, and Pensacola, Florida, culminating in the determination that masses of fluorescent red-yellow and red-orange next to masses of glossy white, comprising a "split" color scheme, provided highest visibility against sky, land, or sea backgrounds.

The early fluorescent dyes, while exceptionally valuable in the field of safety, proved fugitive and impractical. When exposed to direct sunlight, their brightness was measured in terms of about 35 days, requiring removal of the paint and repainting of the aircraft, a long and slow process involving extensive man-hours of labor.

Improved light stability remained the goal at the Navy Laboratory and in pigment manufacturers' laboratories. From their cooperative ef-

fort, a better paint pigment with a brightness life expectancy of about twelve to fifteen months eventually was developed. The particles in this newer paint are dense and non-porous in nature, whereas those of the earlier type of pigment were very porous and resulted in more absorption of moisture and dye molecules near the surface, and weakened colors. The life span of the paint of twelve to fifteen months fitted reasonably well into the pattern of Naval airborne operations. The fluorescent coating is applied over the Fleet's combat color schemes. It is easily removed by solvents when the airplane is deployed from the Continental United States to task forces at sea and the camouflage color scheme must again be reinstated. The new paint behaved satisfactorily in application and durability.

In 1956 the Chief of Naval Operations authorized the first high visibility color scheme for Fleet aircraft operating in high density air traffic in the Continental United States or its possessions. By 1958 a large number of Naval aircraft carried the high visibility fluorescent finish, to aid in minimizing the mid-air collision problem.

Two types of improved fluorescent paint were developed and authorized for Navy use. One was a solvent-removable type developed by the Aeronautical Materials Laboratory which provided ease of removal and re-application without effect on the underlying finish, when the brightness had dropped to an unacceptable level. This type had the added advantage that it permitted retention of the underlying camouflage color scheme on models which may be temporarily assigned to training use, but which must remain capable of deployment to combatant forces on short notice. The other type was one which cannot be so readily removed but for which more experience existed at that time as a result of service applications in the past on a variety of aircraft. The fading characteristics of the two types of paint under the same exposure conditions proved essentially similar.

The Bureau of Naval Weapons program called for application of the second type of fluorescent paint by the Bureau's Overhaul and Repair Departments on aircraft undergoing overhaul, and application of the solvent-removable type by operating activities or their supporting maintenance activity. Under the plan, all trainers and all 4-engine and 2-engine transport landplanes in the Naval air establishment, operating predominantly within the confines of the continental United States, were painted with fluorescent finish. Ten gallons of red-orange paint and 5 gallons of clear overcoating per aircraft may be assumed to be the requirement. However, the exact amount used necessarily varies with the size, type and model of aircraft.

Over 150,000 gallons of fluorescent paint have been applied to military aircraft in the past year or so. Recent Military Specifications MIL-P-21563 (semi-permanent) and MIL-P-21600 (removable type) call for the use of high grade acrylic resin systems and for a pigment concentration of almost four pounds per gallon. Use is currently limited only by tactical reasons, these coatings being of sufficient quality for use on Navy's latest supersonic aircraft. A dry film thickness of approximately 3 mils is required to obtain full fluorescence with a good degree of lightfastness.

These specifications also call for a clear, unpigmented acrylic lacquer overcoating to be applied over the fluorescent paint. Such a finish provides a "cleaner" surface, both aerodynamically and in regular maintenance, since the flat finish of the fluorescent paint tends to become soiled easily by fuels, lubricants, etc.

The philosophy behind issuance of Military Specifications is to make this market available to all interested, qualified paint manufacturers. Another accomplishment resulting from the establishment of the fluorescent paint specifications was approximately a 50 percent reduction in cost of these paints.

2. Heat Resistant Aircraft Finish.

Simultaneously with increases in speeds and performance of Naval aircraft, the necessity for protective coatings on parts subjected to elevated temperatures; e.g., engine exhausts, fuselage adjacent to the exhaust, gun-blast wing areas, jet-propulsion engine parts, etc., became urgent in the late 1940's. In addition, the corrosive action of the environment on ferrous metals is markedly accelerated at high temperatures. The heat-resistant coatings in use at that time left much to be desired, and were, in most cases, unsatisfactory above 600°F. The development of a satisfactory heat-resistant organic coating was expected to eliminate a serious condition that then existed, and one that would become aggravated with jet-propelled and other high speed planes.

This research problem dealt with the development of an aircraft finish to be used on steel surfaces exposed to temperatures up to 1000°F. The coating was to have the application characteristics of a conventional paint, and was to produce the desired properties by air drying or baking at a maximum temperature of 300°F. In addition, the coating was to maintain the requisite durability, adhesion, flexibility, etc., that

would be encountered in service. It was requested at the start of this study at certain Universities under the Bureau of Aeronautics (now Bureau of Naval Weapons) research contracts, that any investigations in the fields of ceramics and porcelain finishes be omitted, as a project of this type of application was already under investigation elsewhere.

The primary requisite of any vehicle to be used alone as a high temperature protective coating is that the vehicle will be resistant to the effects of oxygen at the desired temperature. Attention was therefore focused on two types of vehicles; one, those vehicles whose thermal stability was such that they would withstand the temperature, but of such a chemical nature that they would oxidize; two, vehicles whose chemical constitution made them thermally stable and oxidation-resisting at the high temperature involved in this problem.

(Miss) Marie B. Pfeiffer, Information Specialist, Bureau of Naval Weapons, majored in journalism at Johns Hopkins University, and did post-graduate work in aeronautics at American University. She served as editor-in-charge of printing, Enoch Pratt Free Library, Baltimore; Industrial Specialist, Printing and Publishing, Office of International Trade, Department of Commerce; and International Aviation Research Analyst in the Civil Aeronautics Board prior to becoming a member of the National Production Authority Industry Advisory Committee on chemical, rubber and forest products. She is a member of the Aviation/Space Writers Association, and author of numerous published articles on subjects such as international book trade, copyrights, patents, Walsh-Healey Act, value engineering, weapon systems management, TRANSIT navigational satellites, liquid rocket engines, rocket propelled ejection seats and fluorescent paint research and development.

Alfred M. Malloy has been with the Bureau of Naval Weapons and the former Bureau of Aeronautics since 1940. He received his B.S. degree in Chemistry from Carnegie Tech and his M.S. degree in Chemistry from Michigan State. He was half-time Research Assistant in the Chemistry Department of Michigan State and also half-time Research Assistant at the University of Michigan. He was engineer in charge of finishes and corrosion in the Bureau of Aeronautics and when the new Bureau of Naval Weapons was formed, was named Supervisory Materials Engineer in charge of Materials Protection. During World War II he served in the Navy with the rank of LTCDR. He is active in the Naval Reserve, with the rank of Commander. Formerly Commanding Officer of Reserve Composite Company 5-55; he is also Bureau of Naval Weapons Consultant to the American Ordnance Association and a member of honorary scientific fraternity Sigma Xi. He has published scientific articles on electroplating, painting, colloidal behavior and adhesion. His hobbies are weekend golf and oceanography.

Seymour Kaplan is the Bureau of Naval Weapons engineer responsible for the development of organic protective coatings and processes for use on Navy and Marine aircraft, weapons and related equipment. He has been in the materials engineering field for more than twenty years, originally as a chemist at the Naval Gun Factory (now Naval Weapons Plant), where his major interests were metals and protective materials. This was followed by a period in the Army as a Technical Specialist assigned to work on preservative materials. Since 1946 he has been a Materials Engineer in the Bureau of Aeronautics (now Bureau of Naval Weapons), originally concerned with over-all aircraft maintenance problems involving materials usage. For the past ten years he has specialized in organic protective coatings research and development. Mr. Kaplan has a bachelor's degree from Brooklyn College with a major in chemistry. He has taken graduate work at the George Washington University and the University of Maryland.

Bearing in mind these two main classes of coatings that might be satisfactory, the following program was intitiated:

a. Use of anti-oxidants and plasticizers in an effort to improve the silicones.

b. Investigation of the phthalocyanines.

c. Investigation of the alkali silicates and ethyl silicate.

d. Attempt to synthesize silicones containing aryl groups, followed by fluorination to determine any improvement in properties.

Various formulations were investigated and were exhaustively tested.

Allied work has been conducted by the Aeronautical Materials Laboratory, but, unfortunately, it has been found that the sole commercially-available materials, namely silicones, in general require too high a curing temperature to develop the required solvent resistance to permit their use, except for components of limited size which can be baked separately. In addition, with the exception of aluminum pigmentation, silicone coatings did not maintain the necessary film properties after prolonged heating at elevated temperatures.

Work is also underway on coatings having intermediate heat resistance, i.e., up to approximately 500°F. Silicone epoxy polyamide coatings appear to be promising.

3. Thermal Reflecting Paints.

Some years back, commercial airlines and the Bureau of Naval Weapons (Bureau of Aeronautics) pioneered in the use of white coatings on the roofs of transport aircraft to help reduce the cabin temperature. We all know that the roof of your dark colored car is hotter to the touch than one with a white surface. The principal is simply that solar energy (both the visible and the infra-red) is better reflected by light colors (the best being white) than from dark surfaces.

This same principle is used as a protective measure for aircraft having a nuclear weapon delivery capability to prevent the thermal energy of the bomb burst from overheating the surfaces of the delivering aircraft. By use of high reflecting white paints on the thin gauge, structurally critical surfaces of aircraft, the possibility of successful completion of such missions and safe return of the pilot is promoted. The Bureau of Naval Weapons desires to further increase the performance of white paints by improving their reflectance beyond the visual range; that is, in the near infra-red and near ultra-violet regions. One approach is by a change to a newer type of pigment to replace the titanium dioxide or perhaps by some treatment of the TiO_2.

4. Rain-Erosion Resistance.

The Military are currently using neoprene type coatings on the leading areas of glass fabric laminate type radomes to prevent destructive damage due to high speed flights through rain. For example, standard lacquers at a speed of travel of 500 m.p.h. through 1″/hr rainfall will last approximately 30 seconds; the MIL-C-7439 neoprene coating will last approximately 60-90 minutes. The difference in performance is related to the resilient properties of the neoprene which, in a 10-12 mils thickness, cushions the bullet-like impact of rain to prevent damage to the radome structure, and is itself affected only negligibly. Lacquers and enamels and non-elastomeric types apparently do not absorb the energy of impact and are eroded away in relatively short order. The same neoprenes when tested at 1500 m.p.h., however, last only a few seconds. The inability to protect fiberglas type radomes at really high speeds necessitates use of ceramic type radomes which can take such high speed rain impacts.

The Bureau of Naval Weapons could possibly find use for elastomeric type coatings wihch could withstand high speed rain erosion. A factor which would be significant is that these coatings would have to be inherently heat resistant, too, to prevent degradation resulting from aerodynamic heating.

5. Improved Protective Finishes.

The yearly cost of protection of aircraft metal surfaces against corrosion amounts to a very large sum. This can be readily understood when it is considered that Naval aircraft are constructed from a number of types of metals and alloys. Fabric (and dope for tautening fabric has little use on modern military aircraft. The choice of metals depends upon the function to be fulfilled, and the physical properties required of the part. The major portion of the airplane is fabricated from aluminum alloys 3003, 2024, 5052, 6061, 2014 and 7075 because of weight and other physical considerations. Sheets for wings and fuselage are generally fabricated from 2024, 2020 and 7075 aluminum alloys, both clad and unclad, the clad having better corrosion resistance.

Parts constructed of steel are arresting hooks, armor plate, bolts, fittings such as turn-buckles, landing gear, anti-friction bearings, control cables, engine mounts, major engine parts, etc. Landing wheels, certain engine and airframe components, etc. are made of magnesium alloys. More recently, because of the increased operating temperatures encountered in high performance aircraft, titanium alloys have replaced some alumi-

num in airframe sheet components, particularly in those areas operating at temperatures above about 300°F. These applications include a number of wing and fuselage assemblies, shrouds, ducting, and to an increasing extent titanium alloy fasteners. In aircraft engine compressor sections titanium has replaced steel in a number of instances for blades, discs and compressor case assemblies. In addition, sundry metals such as stainless steel, cooper, brass, and nickel alloys are used for various applications throughout the airplane. Beyond this are the newer structural metal possibilities now in the developmental stage, which include beryllium and vanadium. Beryllium offers very attractive weight savings potential with high strength and stiffness, while vanadium offers exceptional strength at temperatures up to 2000°F.

Steel and magnesium alloys require exceptional protection to prevent corrosion of the parts. The presence of dissimilar metals in contact with each other also presents an aggravated corrosive condition, since the corrosion effect due to chemical action of the suurounding environment is increased by the galvanic action of the dissimilar metal contact.

Examples of corrosive conditions likely to be encountered in service and requiring precautionary protective measures are: severe corrosion of internal parts of engines; interior surfaces of wings, etc., due to condensation of moisture; pitting and general corrosion due to salt spray and coral dust; and accelerated galvanic corrosion of aluminum alloy in contact with poorly plated steel fittings. There are others too numerous to list here.

Since structural strength cannot be compromised, inherent corrosion resistance of the metals employed is of necessity subordinated to strength considerations in aircraft construction and, consequently, organic coatings are called upon to achieve the final objective.

In the manufacture and maintenance of Naval aircraft, the interior and exterior of parts such as wings, fuselage, cowling, struts, empennage and floats are treated with protective systems for the environment involved, in strict conformance with Specifications MIL-F-7179 and MIL-F-18264. These general specifications present detailed procedures to be followed, i.e., the methods and materials required for cleaning, surface treatment, and application of finishes and protective coatings.

The Bureau's program is to constantly upgrade the protective qualities of the finishes and to extend their durability in the interest of reduced maintenance costs and less down-time of aircraft. As part of this program, newer developments in raw materials are constantly being evaluated. Examples in this category include epoxies and polyurethanes which in laboratory tests exhibit outstanding performance, but at some sacrifices in ease of application and speed of production.

As yet the production reliability of such materials for aircraft applications has not been fully established. Services tests with epoxies are in progress on a number of aircraft for this purpose. Some aircraft manufacturers, in their early attempts to employ epoxy coatings, have reported that the performance of such coatings has either been outstanding, or very bad, and that the major factor appears to be the surface preparation of the metal. Proper surface preparation appears to be more critical for the epoxy system than for the lacquer system.

The Bureau of Naval Weapons recently promulgated Specification MIL-C-22750 (Wep) for an epoxy-polyamide topcoat material and MIL-C-22751 (Wep) covering the application procedures. These specifications are still considered in the evaluation stage and further work is being done on the development of epoxy primers to be used with the MIL-C-22750 topcoat. The question still remains as to whether a full epoxy primer/epoxy topcoat system may be impracticable to strip at a later date in the service life of the aircraft, particularly after long term exposure to severe heat. Considering the hard service given aircraft, it can be appreciated that the finish, regardless of type, will be scratched and marred in time and will require renewal after a number of years. Overcoating is undesirable because of added weight and unreliability; hence if these finishes cannot be stripped, serious problems may develop.

There are two major types of air-drying epoxy coatings; one employs an amine type catalyst and the other a polyamide variety. The amine variety is potentially more toxic and dermatitis-inducing than the polyamide variety. Specification MIL-C-22750 prescribes the polyamide variety in the interest of safety of personnel even though this increases the drying time of the finish, compared to epoxies catalyzed with amines. The Bureau of Naval Weapons has had unfortunate experience with other type materials which had been used for many years without any personnel injuries until all of a sudden, a number of painters were hospitalized due to the toxic effects of the paint ingredients. Investigation showed that a new application and inadequate ventilation were involved. Understandably, the

Bureau of Naval Weapons prefers to employ relatively safe materials.

Investigation of the feasibility of exploiting the superior toughness of polyurethane coatings has been conducted for a number of years by the Bureau of Naval Weapons and its predecessor, the Bureau of Aeronautics. The excellent solvent resistance and superior mar-resistance of polyurethanes make these coatings particularly attractive for aircraft. Until recently, problems of moisture-sensitivity (resulting in gas formation) made the material extremely tricky to handle in a production process, but progress in overcoming this difficulty has been achieved by addition to paint a small percentage of "moisturegetter."

The problem of toxicity of the isocyanate-monomer still, of course, requires attention. Uniformity of the resin must still be assured, to obtain consistent properties, perhaps by specifying the viscosity, molecular weight and OH content of the resin.

At present, trial application on the entire exterior of a carrier type plane is being conducted by at least one Navy aircraft contractor, and, in conjunction with the Bureau of Naval Weapons, the performance of this finish will be closely followed. The polyurethane topcoat is applied over an epoxy primer, to obtain a combination of the high adhesion properties of the epoxy to surface-treated metal, the superior scuff-resistance of the polyurethane, and high intercoat adhesion of the two types of material. Six months weather exposure tests of the material, to date, confirm the soundness of this approach.

FURTHER OBJECTIVES:

Further objectives of the Bureau of Naval Weapons' program are to advance the science of finishing military weapons and to develop improved testing procedures. Examples of research investigations either underway or planned by the Bureau at this time are:

1. **Physical and chemical properties of films** of organic finishing materials and the chemical, physical and electrical forces existing at the metal-film interface.

There is an urgent need for suitable, rapid procedures for prediction of the performance of the coatings by examination of the physical and chemical properties of un-aged films, without the necessity of long-term, outdoor weather exposure tests. Morever, since the protective qualities of a film are primarily dependent on its degree of adhesion and porosity, improvement of these characteristics is of prime importance and a study of these properties is a necessary prerequisite to improvements.

2. **Improved Inhibitive Pigments.** Corrosion is both chemical and galvanic in nature. By chemical we mean direct chemical solution, as steel in acid or aluminum in alkali. This type of corrosion is relatively minor on aircraft. Galvanic corrosion is related to the battery effect of placing dissimilar metals in contact; for example steel against aluminum, or aluminum against magnesium. This type of corrosion is difficult to control using present coatings. Although the coatings are effective for a time, pinholding, cracking or porosity develop with service and entry of moisture and other corrosive elements permit the battery action of the dissimilar metal contact to result in aggravated corrosion. Battery action can be prevented in solutions in a beaker, but whether as satisfactory results can be obtained by incorporating the pigments into paint coatings has yet to be established for certain metal combinations.

3. **Two-Coat Paint System.** The standard Bureau of Naval Weapons lacquer system is a three-coat system, i.e., it employs three different materials; wash primer, zinc chromate primer and a lacquer topcoat. The epoxy system presently being evaluated is a two-coat system, but it employs slow drying materials. Development is underway of a lacquer system requiring only a strongly inhibitive wash primer plus the topcoat. This would permit accelerated production and easier squadron "touch-up", and also reduce the possible sources of intercoat adhesion failures.

4. **High Temperature Paint System.** Work is being sponsored by the Bureau of Naval Weapons at certain Universities and Research Institutions on the development of air-drying, high temperature resistant, coatings. For example, one is experimenting with synthesizing heat-resistant titanium esters, and another is developing inorganic type paints based on phosphate esters and inorganic oxides or ceramic frits.

5. **Other Investigations** include finishes for specialized uses on Naval aircraft, and study of promising resins and pigments for these uses.

The Bureau of Naval Weapons, Washington, D. C., has a Materials Protection Section (Code RRMA-5) and a Surface Coatings and Color Unit (Code RRMA-53) which can help those interested in having Navy requirements on specific problems defined. Please address inquiries to Mr. A. M. Malloy, Head of the Materials Protection Section, Bureau of Naval Weapons, or Mr. S. Kaplan, Project Engineer for Surface Coatings and Color, Bureau of Naval Weapons, 21st Street and Constitution Avenue, N.W., Bldg. W, Washington 25, D. C.

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